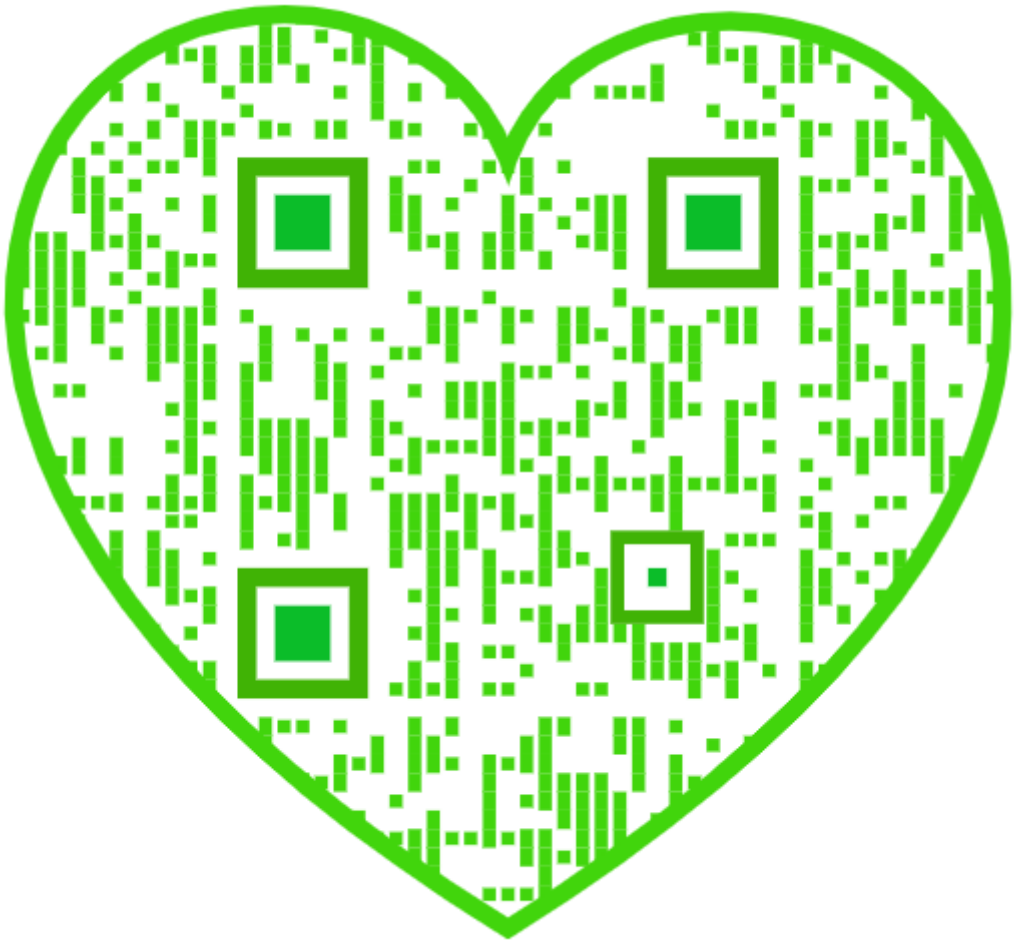

INTERIOR OF LEHUA FOREST.

HELIOTYPE CO., BOSTON.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF FORESTRY—BULLETIN No. 48.

GIFFORD PINCHOT, Forester.

THE FORESTS

OF THE

HAWAIIAN ISLANDS.

BY

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WASHINGTON:

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF FORESTRY,
Washington, D. C., March 3, 1904.

SIR: I have the honor to transmit herewith a report entitled "The Forests of the Hawaiian Islands," by William L. Hall, in charge of Forest Extension in the Bureau of Forestry, and to recommend its publication as Bulletin No. 48 of the Bureau of Forestry. The report is made in consequence of a reconnoissance of the forests of the islands during 1903, and its recommendations form the basis of a forest policy which is being put into effect by the Territorial government.

The eight plates which accompany the report are necessary for its proper illustration.

Very respectfully,

GIFFORD PINCHOT,
Forester.

Hon. JAMES WILSON,
Secretary of Agriculture.

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THE FORESTS OF THE HAWAIIAN ISLANDS.

There are two thoroughly distinct kinds of forest in the Hawaiian Islands. One kind occurs near sea level, in the drier portions of the islands, and is valuable on account of the timber and other products which it yields. The other kind is found on the mountain slopes, where the rainfall is heavy. It has little commercial but high protective value. In no case do the two forests meet.

THE ALGAROBA FORESTS.

The forests which occur near sea level consist of a single species, and this introduced. It is the mesquite of the southwestern United States and Mexico (*Prosopis juliflora*), and is called algaroba. The first algaroba tree in Hawaii grew from a seed planted in 1837 by Father Bachelot, founder of the Roman Catholic mission. This tree, which is about 2 feet in diameter and 50 feet tall, yet stands in thrifty condition at the corner of Fort and Beretania streets, Honolulu. It is the progenitor of at least 50,000 acres of forest, which is fairly well distributed over the different islands.

On the island of Oahu the algaroba forest, covering densely about 20,000 acres, extends in a narrow, almost continuous belt along the south and west coasts. In this situation it is fully protected from the northeast trade winds, which blow with great regularity from March to November—exposure to which it can not endure. The young trees are now growing in great numbers as high as 1,500 feet above the sea. It is supposed by some people that algaroba is able to grow at this elevation only by gradual adaptation. Starting at sea level, the trees were at first acclimated only to an elevation of a few hundred feet, but successive generations growing higher and higher up the slopes have at last produced trees which are able to grow at the altitude named. Indeed, since the trees now found at 1,500 feet are all young and thrifty, it seems probable that they will extend much farther up the mountain slopes than they have yet done.

On the other islands the algaroba occupies the same relative position, reaching up the dry slopes to an elevation of several hundred feet. The land which it has taken possession of is usually so stony, arid, and precipitous as to be utterly worthless for other purposes. Therefore the advent of this tree is generally welcomed by the landowner.

In Hawaii the species grows much denser, as well as both taller and straighter, than in the United States. Where fully established it shades the ground so perfectly as to keep out all competitors, and attains a height of from 50 to 60 feet. While there are no records to support the opinion, it is believed by some that the districts covered by algaroba receive more local showers than formerly.

Situated as they are, the algaroba forests are more accessible than the other forests of the islands. Indeed, there are hundreds of cases where the forest has taken possession of old feed lots and pastures on farms and sugar plantations, and even on vacant lots in towns. Some of the suburbs of Honolulu are thickly grown up with algaroba. The wood, which is valuable for fuel, sells at the plantations and in Honolulu for $9 to $10 per cord. It lasts well in the ground when used as a fence post. Both fuel and fence posts are in such great demand that there is extensive cutting in these forests.

Clean cutting is the method generally employed, and is entirely conservative, since the growth renews itself rapidly by both seeds and sprouts. Within three or four years from the time of cutting the trees again take complete possession of the ground, and attain a height of 20 to 25 feet.

An important feature of the algaroba is the value of its pods as food for stock. Pods are borne with great regularity and in abundance after the trees are 3 years old. They ripen during the summer months and fall to the ground, where they are either eaten by cattle, horses, and pigs, or are picked up to be fed. In eating the pods stock do not crush the small, horny seeds, which pass on through the alimentary system and are prepared for quick germination by the action of the digestive fluids. Stock are, therefore, solely responsible for the rapid and wide spread of this tree. Nor can it be said that their presence in the algaroba forests is noticeably injurious either to standing trees or to reproduction. No doubt they do to some extent browse on young seedlings, but in the abundance of reproduction this has no perceptible effect upon the stand.

Forming, with the exception of grasses, the most important animal food in the islands, the pods are a boon to stockmen, who fatten cattle on them during July and August, when pastures are usually dry; to liverymen, who feed them mixed with corn meal or bran during a large part of the year; and in fact to all who have to supply feed for horses, cattle, or hogs.

The algaroba forests are a valuable asset for Hawaii; they have no destructive enemies; they have tremendous powers of reproduction and extension; and, best of all, they are so highly appreciated because of the character of the ground which they cover and the products which they yield that they will be cared for by the individual without special action on the part of the government.

THE NATIVE FORESTS.

All of the five important islands are mountainous, their highest points ranging from 4,030 feet on Oahu to 13,760 feet on Hawaii, and all the mountains are to a considerable extent forested.

SITUATION.

The forests are distributed on the different islands approximately as follows:

KAUAI.

The forest covers the highest portions of the mountains toward the central part of the island, extending down to an elevation of about 1,200 feet on the windward (northeast) slope, and 1,500 feet on the leeward slope. It is practically all in one body, surrounding Mount Waialeale.

OAHU.

There are two distinct ranges of mountains on this island, both of which are forested. The Koolau Range, on the east side of the island, has much the larger forest. On this range a fairly good growth of timber extends from Pupukea and Paumalu on the north to Palolo on the south, above an elevation varying from 1,000 to 1,500 feet. The forest extends over the highest peaks of the range. The Waianae Mountains, which form the western rim of Oahu, support a fair growth of forest above 2,000 feet. As the lower elevation of this range receives less rainfall than the Koolaus the forest is limited to higher elevations.

MOLOKAI.

The only forest now remaining in the mountains of Molokai is found at elevations above 1,500 feet at the east end of the island. This forest is extremely inaccessible on account of the precipitous character of the mountains.

MAUI.

The western peninsula of Maui, though small, has mountains over 5,000 feet high. These are forested above 1,200 feet on the windward side and 2,000 feet on the leeward side.

The windward slope of Haleakala, which rises to an elevation of 10,030 feet on the main part of Maui, is densely forested up to an elevation of 8,000 feet. In this case the forest extends down to within 1,000 feet of the sea level, or even lower. The slope which it occupies is cut by so many deep gorges that it is practically inaccessible, and has never been explored. This forest extends around the eastward slope of Haleakala, through the district of Hana, and a belt

of it has in the past extended almost entirely around the mountain, at an elevation of from 4,000 to 6,000 feet. This belt is now largely destroyed on the western and southern sides of the mountain.

HAWAII.

The windward slopes of the Kohala Mountains of northern Hawaii are forested above the sugar plantations to the summit of the mountains. But on the leeward side the forest has been destroyed almost to the summit. Between Honokane and Waipio, where the mountains break off sharply into the sea, the forest extends to sea level. From Waipio to Kukaiau, in Hamakua, but a thin belt of forest now remains adjacent to the sugar plantations. This forest forms a part of the Parker ranch, and all portions of it are grazed. In the southern part of Hamakua, where the influence of Mauna Kea comes in to increase the precipitation, the forest rapidly widens and reaches in a great loop around Mauna Kea at an elevation of from 6,000 to 8,000 feet. In Hilo it extends to a width of 20 to 25 miles on the gradual slope of Mauna Loa, but in Puna it is brought to a sudden limit where the rainfall ceases and the desert begins. In Kau another forest begins, and extends continuously through western Kau and Kona at elevations of 3,000 to 6,000 feet.

TROPICAL CHARACTER OF FORESTS.

The native forests are distinctively of tropical character. None of the familiar trees of the north temperate zone are present. The observer looks in vain for oaks, maples, pines, or spruces. There is one representative each of Sapindus, Sophora, and Zanthoxylum, and two or three of Acacia, but all differ distinctly from their congeners in the United States.

FOREST TYPES.

The forests are composed mainly of five distinct types: Pure growths of lehua, koa, mamane, and kukui, and mixed forests, which are made up of koa, koaia, kopiko, kolea, naio, pua, and other species.

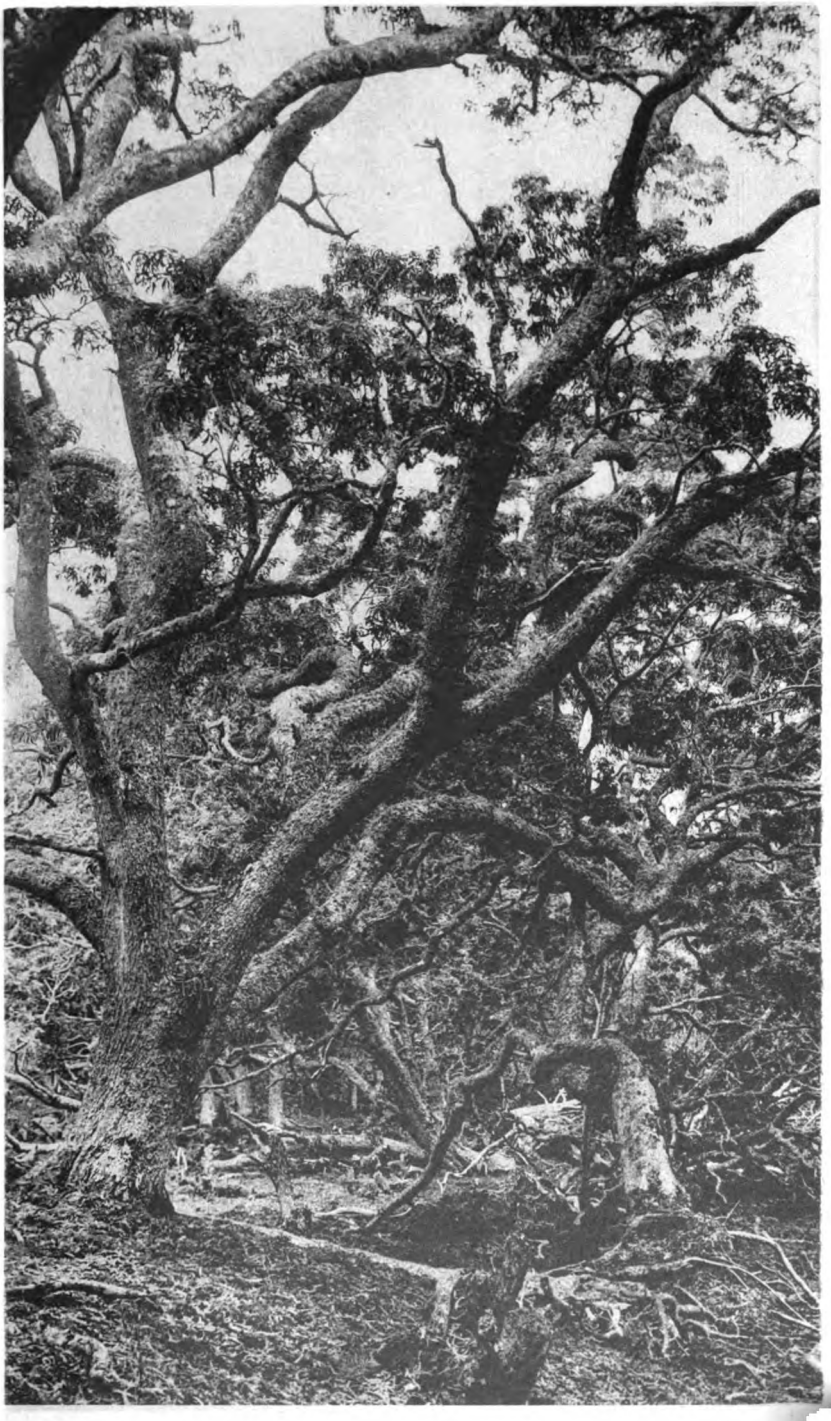
LEHUA.

The ohia-lehua (*Metrosideros polymorpha*), which forms pure stands or grows with a small admixture of koa, naio, kopiko, and pua on all the different islands, is the typical forest of regions of very heavy rainfall, such as northeast slopes and mountain tops under 6,000 feet elevation. It comprises probably three-fourths of the native forest.

The lehua of itself seldom forms a dense stand. The trees are apt to grow far apart, and always have small, thin, upright crowns, which are very intolerant of shade. Under varying conditions in the forest the trees grow from 30 to 100 feet high. In the best forests, which

FIG. 1.—IE-IE VINE IN LEHUA FOREST.

FIG. 2.—UNDERGROWTH IN A MOUNTAIN COVE.



A Hawaiian Koa Forest.

Heliotype Co., Boston.

always occur where the rainfall is greatest, many of the trees reach a diameter of 4 feet, a height of 100 feet, and a clear length of 40 to 50 feet. The lehua trunk is straight, often twisted, deeply ribbed near the ground, and frequently divided into several roots 10 or 12 feet above the ground. The root system is very shallow, often spreading right on the surface of the mineral soil.

Though the stand of trees be thin, the normal forest, on account of an abundant and luxuriant undergrowth, is impenetrable except as one cuts his way with knife and axe. Many of the trees support climbers such as the ie-ie vine, which grows into the crowns and may lace together with rope-like stems the trees of an entire forest. Then there is the fern growth, marvelous in its variety and luxuriance. With species which range in height from a few inches to 30 feet, growing both on trees and on the ground, and running the whole scale of shade endurance, the ferns do much toward making the virgin lehua forest the impenetrable, dark jungle which it often is. Mosses in places cover the ground, fallen logs, and tree trunks several inches deep, and grow in bunches over a foot thick on suspended vines and drooping twigs, giving an appearance of weird drapery.

Undergrowth of this kind affords a great quantity of humus, and possesses an enormous capacity for holding water. Even in a rather dry time one may squeeze enough water from a few handfuls of moss to obtain a good drink. Fallen logs, fern trunks, and all kinds of débris are constantly saturated. Mountain ridges less than a rod wide at the summit are often boggy where these conditions prevail.

In so dark a forest it seems anomalous to find the lehua, a tree of pronounced intolerance, reproducing itself generation after generation. It does so through its singular habit of germinating on both standing and fallen trees, and especially on the fibrous trunk of the tree fern, which is admirably suited to its needs. Only in such places can it get the light it requires. As soon as it germinates it sends down several roots, which enter the ground and perform the normal functions of support and nutrition. When the host decays, the tree is left standing on these roots, which to all appearances are simply divisions of the trunk. The natives have an adage that the amau (tree fern) is the mother of the ohia lehua. (See frontispiece.)

As one passes above an elevation of 4,000 feet, or out of the districts of greatest rainfall, the lehua relinquishes its prominent place and mingles with other species, such as the naio, kolea, kopiko, koaia, and koa.

Lehua wood is of reddish color, heavy, and in drying checks and warps so badly as to be of little commercial use except for fuel. It has been used frequently by the natives in the building of log houses, and has also been used on the islands for railroad ties.

The lehua forms the tallest and most impenetrable forests on the

islands, and because of its character and of the fact that it covers districts where the rainfall is greatest and the mountains most precipitous, it forms the most valuable protective forest. Nearly all the districts which accumulate a large supply of water available for irrigation and fluming purposes are covered by lehua forests.

KOA.

Besides growing in mixture with lehua, koa (*Acacia koa*) forms pure stands over extensive tracts in Hawaii and Maui. Koa has a leaf which is almost indistinguishable from the Australian blackwood (*Acacia melanoxylon*), which has been commonly planted in southern California and to which it is closely related botanically. It is naturally a spreading tree with a short trunk, growing in somewhat scattered stands. Occasionally under normal conditions it reaches a diameter of 6 or 8 feet and a height of 75 feet. Much greater height than this is reported. (See Pl. III.)

In crowded stands the koa is forced into a long, slender, but seldom straight stem. It is intolerant of shade at all ages, and will not germinate or grow without a large amount of light. Koa also has the fern undergrowth which characterizes the lehua, though as it grows in somewhat drier situations its undergrowth is usually not so luxuriant. The ie-ie vine especially is seldom seen in a koa forest.

Koa is the one fairly abundant tree of the Hawaiian forests which is valuable because of its lumber. It is a highly prized cabinet wood, which has been largely used on the islands and has also been exported in limited quantities. Its color varies through many rich shades of red and brown; its grain is fine and indistinct. Curly koa is especially prized, but is very rare. Most of the best koa on Maui has been cut, but an extensive mature forest exists in Hilo and Puna at elevations of from 4,000 to 6,000 feet. This forest is but little known, but seems to contain some magnificent timber and to be in a good state of reproduction. Practically all of this forest is upon accessible government land, and could be utilized to great advantage should the government build a road to it and establish a sawmill for working up the mature trees.

MAMANE.

Mamane (*Sophora chrysophylla*) grows successfully only on the high slopes of Mauna Kea and Hualalai. It originally extended down to an elevation of about 4,000 feet on the north slope of Mauna Kea, but was killed out at this elevation apparently by the encroachment of Bermuda grass (manieie). But little of it is now found except between 6,000 and 8,000 feet, at which elevation it forms a belt clear around Mauna Kea. In this situation it is notable for its rapid extension within the last few years both up and down the mountain. This extension has taken

place in spite of heavy grazing, and forms the only example of the extension of the natural Hawaiian forest under such conditions. Unlike the case of the algaroba, cattle seem in no way responsible for the extension of the mamane, as they eat neither the seed nor the fruit. The seed, borne in great profusion, is readily disseminated by wind and water. Mamane also grows abundantly on Maui, particularly on the slope of Haleakala, at from 6,000 to 8,000 feet above sea level. It is not abundant on the other islands.

Mamane is the best post timber of the native forest, and for this reason is a useful tree to the ranchman. It is not of great value as a soil cover, because it neither forms a dense stand nor is supplemented by a heavy undergrowth.

KUKUI.

Kukui (*Aleurites triloba*), a handsome tree with large, silvery leaves pointed like the leaves of the California sycamore, characterizes the bottoms and sides of gulches and streams to an elevation of 2,000 feet. It is frequently called candlenut, because of the oily nut which it produces in abundance, and which in olden times was used by the natives for illumination. The kukui has value only as a cover for the steep slopes where it grows. In almost all cases it has beneath it a dense undergrowth of fern. In very moist coves, protected from severe winds, the wild banana often forms a part of its undergrowth. Near the edges of streams the kukui is frequently supplanted by the ohia-ai, which, in small patches, forms the densest forest to be found in the islands.

MIXED FORESTS.

Mixed forests of koa, koaia, kopiko, kolea, naio, pua, and other species occur on nearly all the islands, particularly on portions too dry for the species above named to form pure forests. Thus, on approaching a forest area from a desert, one encounters first a mixed forest and afterwards a pure forest of some of the kinds mentioned. Forming thus the edge of the natural forest, and occurring often on plains or gentle slopes, the mixed forests have suffered more from grazing than any other type. Very many of them have been almost entirely exterminated, as, for instance, those on the leeward slopes of the Kohala Mountains of Hawaii and those on the upper portion of Kula, on Maui. The mixed forests have often been injured by grasses, particularly the Bermuda grass, which thrives under the same natural conditions.

LIMITS OF THE ORIGINAL FORESTS.

Originally the forests were limited only by such natural conditions as lack of rainfall, elevations, and lava flows.

The northeast trade winds keep the windward mountain slopes saturated by frequent rains during the greater part of the year, and on

these slopes, at elevations of 1,500 to 3,000 feet, where the rainfall is greatest, is found the heaviest forest. Toward regions of lessened exposure to trade winds and decreased rainfall the forest becomes thinner and of poorer quality, and on the leeward, where the rainfall is in places less than 30 or 40 inches per year, there was often no forest at all. Probably the area which originally bore no forest because of insufficient rainfall was quite large, for it is certain that all of the important islands now have large tracts to which no trees of the native forests are adapted.

Elevation has put a sharp limit to the forest on the islands of Hawaii and Maui at from 6,000 to 8,000 feet. This leaves very large areas of Mauna Loa, Mauna Kea, Hualalai, and Haleakala devoid of forest, and they have always been so. The mountains of the other islands, being under 6,000 feet, are forested to their summits. Six to eight thousand feet is a surprisingly low timber line, considering the favorable conditions of soil, moisture, and temperature which prevail at that altitude in Hawaii. The sufficient reason seems to be that the species composing the native forests are all representatives of the torrid zone, and in these islands, which lie right at the edge of the Tropics, find their limit at the low altitude named.

On the slopes of Mauna Loa lava flows have put a sharp limit to the forest in a number of places. The flow of 1881, which ran from near the top of the mountain almost to the sea, cut a wide swath through a dense forest for fully 15 miles. Many previous flows had resulted similarly, and while the forest is slowly replacing itself on the older flows, hundreds of years are required for the lava to decompose sufficiently to support a normal growth of forest. Many thousand acres which once must have been well forested are now surfaced with lava rock (pahoehoe), and support only a meager growth of fern and stunted trees. Slowly this rock is decomposing, and as it decomposes the forest improves.

RAPID DECADENCE OF THE FOREST.

The above were the chief agencies restricting the forest up to about one hundred years ago. Since that time various deleterious agents have worked so effectually toward the destruction of the woodland that every forest in the islands has been reduced, until it is now only a fragment of what it was originally. The island of Molokai well illustrates this point. This island, 38 miles long by 8 miles wide, has a range of mountains over 4,000 feet high at its eastern end, drops to a low plain in the center, and rises to 1,380 feet near the western end. Originally all the eastern end well down to the central plain, and the highest part of the western end, were heavily forested. The plain was park-like, with scattering groves of trees. There is little at present even to indicate former conditions. All the western end is bare.

FIG. 1.—FOREST NEARLY RUINED BY GRAZING, NORTH KOHALA, HAWAII.

FIG. 2.—FOREST ENTIRELY RUINED BY GRAZING, MAUI.

FIG. 1.—GRAZED LAND ON LEFT SIDE OF FENCE; RIGHT SIDE PROTECTED FOR SEVEN YEARS.

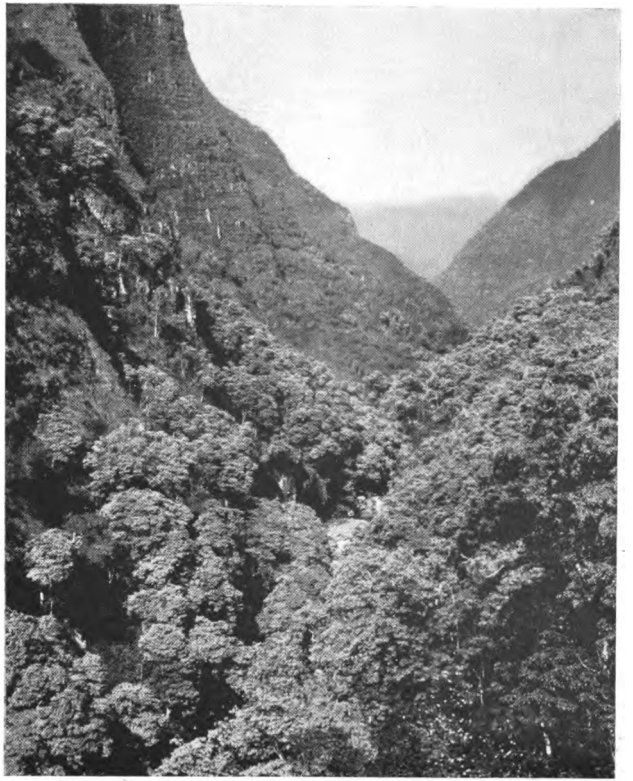


FIG. 2.—KUKUI FOREST, BOTTOM AND SIDES OF DEEP GULCH.

GRAZED AND UNGRAZED LAND ON MAUI, SEPARATED BY AN IRRIGATING DITCH.

FIG. 1.—CLEARING ON A HOMESTEAD, HAMAKUA.

FIG. 2.—A WELL-FORESTED WATERSHED, MAUI.

The trees are gone from the plain, and also from the western and southern slopes of the mountains at the eastern end. Only a few thousand acres of the highest south slopes and the precipitous north slopes of the mountains are now covered by growing forest. Stretching around the living forest is a wide belt of leafless timber, which has died within the last decade, but has not yet fallen.

Each of the other islands exhibits just the same conditions. More marked examples of declining forests can scarcely be imagined than exist in the districts of Hamakua and Kohala in Hawaii, and Kula in Maui, in which one may pass through thousands of acres of totally dead forest into equal areas of which the forest is in a dying condition, and from these into the small remnant that yet remains thrifty.

No estimate can be given of the ratio of the present forest to that of a century ago. The former area is unknown, and the present forests are so inaccessible and so irregular in shape that a safe estimate can not be made without much further study. But it is certain that the present area, which may not be more than 20 per cent of the islands, is but a small part of what existed at that time. This result has been brought about by perfectly evident causes working unretarded year by year.

CAUSES OF DECLINE.

The principal causes which have brought about the destruction of the forests are stock, insects, grasses, fire, and clearing.

STOCK.

Cattle were introduced into the islands late in the eighteenth century. They were turned out to run at large, and strict laws prohibited their slaughter for a number of years. Under these favorable conditions they had increased to such numbers by 1815 as to be a menace to the forest. Their slaughter was no longer forbidden, but they continued to multiply rapidly. By 1850 boiling plants had been put up in several places for the extraction of tallow, that being the only portion of the animal having any value. These plants were in continuous use until the seventies, and indicate the great numbers of cattle which must have existed during that time. Only within the last few years have cattle been reduced in numbers to conform to the demands of the islands, and placed within fenced paddocks. Numbers of wild cattle still run at large in the various forests, although many have been driven out or shot. Mr. A. W. Carter, manager of the Parker ranch, on Hawaii, estimates the number of wild cattle on Mauna Kea to be 10,000.

That cattle did the first serious damage to the forest can scarcely be doubted when one considers their great numbers and the extent of the forest. At a very early day they must have gone through all the

accessible parts. The more inaccessible and impenetrable parts remained intact till later, for cattle could only work around the edges of these, entering a little further each year; but now in many instances they have gone through the entire forest.

The character of the Hawaiian forest makes it peculiarly susceptible to injury by cattle. The tender, succulent undergrowth is easily trampled down, and much of it, especially ie-ie, banana, and some of the ferns, is excellent food for stock. Yet this undergrowth is a vital part of the forest; without it the ground dries quickly and the shallow-rooted trees soon die.

Goats were introduced into the islands many years ago, and have been particularly active agents of destruction. They are now found on all the important islands. Their work, though localized, is more thoroughly destructive than the work of cattle. Ridges where they rendezvous may be distinguished for miles by their utter barrenness and eroded condition. Goats are especially hard on precipitous slopes. They will lay completely bare places so steep as to be shunned altogether by cattle.

Wild pigs, the progeny of stock introduced years ago, have done some damage on all the islands. They tear up the tree fern, seeking its roots for food.

Deer brought to Molokai in the early sixties have taken their share in the destructive work. Several years ago they had increased to such immense numbers as to damage the forest considerably by browsing on and trampling down the undergrowth and rubbing the bark from the young trees.

INSECTS.

Following the attack of stock have come other agents of destruction. Injurious insects have at times appeared in numbers sufficient to deaden and even eventually to kill the timber over thousands of acres at a time. Ohia-ai, which grows in dense stands in low, wet valleys, was so completely defoliated a few years ago as to be almost ruined. Koa is periodically defoliated. It has upward of a dozen insect enemies which threaten its utter extinction. Borers are even more common than leaf-eating insects. In nearly all cases insects have been most severe where the forest was enervated by grazing. Portions of the ungrazed forest have at times been destroyed by insects, but only in consequence of the headway gained on near-by areas which have suffered by grazing.

GRASSES.

Many thousand acres of forest land despoiled by cattle have been overrun by rank-growing grasses, which have rendered conditions prohibitive of forest reproduction. Probably the worst of these is Hilo grass (*Paspalum conjugatum*), which grows 2 to 3 feet high in

the rainy districts and forms a dense mat several inches thick over the surface of the ground. Tree seeds can not germinate beneath it. Another coarse grass of similar habits is the so-called rice grass (maulike). But it is neither so common nor so prohibitive of reproduction as Hilo grass.

In drier districts Bermuda grass (manienie) obtains such a hold as to prevent forest reproduction, and even to hinder tree growth. Some of the forests of Hamakua and Kohala, in Hawaii, have died from no other apparent cause than a predominant growth of this grass.

FIRE.

Fire has done far more injury in Hawaiian forests than would be supposed in regions of so great rainfall. The most serious fire within recent years occurred two years ago in southern Hamakua. It burned an area 15 miles long and 2 to 4 miles wide, leaving unburned only occasional patches. Trees, undergrowth, and humus were generally completely destroyed. The forest was a normal one for the islands, consisting of a fairly heavy growth of lehua and koa, with a heavy undergrowth of fern and a deep accumulation of humus. Ordinarily this forest could not have been burned, but a severe drought prevailing for several months previously had dried it out to the point where it burned with great rapidity. At the present time the land is covered with fallen trees and débris, and in places a growth of weeds. But little reproduction has as yet taken place, and, as practically all seeds and seed trees on the area were burned, there is no possibility of immediate reproduction. Whatever growth comes up on the land must come from seeds carried in from other places.

Other forest districts, particularly on Kauai and Maui, have also suffered from fire, though there have been no other recent burns so severe as the one mentioned above.

There is distinct evidence of a severe fire upward of fifty years ago in the southern part of Hamakua. This fire burned over a tract of large, though unknown, extent. It killed practically all the forest and undergrowth, and consumed the humus. Its heat must have been intense, for it baked the soil to such an extent that at the present time it shows as a brick-like layer from 2 to 6 inches thick. In many cases it burned the roots of trees several feet below the surface. The forest which has come up on the ground following this fire, though composed of the same species as the ordinary Hawaiian forest, differs from it distinctly in conditions and requirements. The trees have grown slowly and have less than the usual amount of undergrowth, but they have far greater power than the normal forest to withstand grazing.

CUTTING.

The forest has been considerably reduced by cutting. Destructive cutting began by the removal of the sandalwood in the early part of the nineteenth century, and has continued intermittently till the present time. Except the sandalwood and koa, the main uses of the native timber have been for fuel and poles. Large quantities of native timber have been used for fuel in the past, but the demand is now very largely supplied by the algaroba. Most of the sugar mills, which have been large consumers of native wood, have now turned to other kinds of fuel. Some use coal, some oil, and some the tailings of the cane (bagasse). In southern Hamakua and Hilo, in Hawaii, a few of the mills are still consuming a large amount of native wood, and two or three, with surprising lack of foresight, are cutting away the timber which lies just above their plantations and upon which probably their water supply largely depends.

THE CRUCIAL QUESTION ON THE ISLAND OF HAWAII.

At the present time a good deal of land is being cleared for the extension of cane fields and for the establishment of homesteads in Hamakua, Hilo, and Puna. The wisdom of the removal of these forests is a grave question, and there is emphatic difference of opinion concerning it.

The whole northeast coast of Hawaii receives a variable but heavy rainfall, and was originally forested to the shore of the ocean. Years ago this region was found to be adapted to the growth of sugar cane without irrigation. Plantations sprang up rapidly, and soon formed a continuous chain from the north point of Kohala to several miles south of the town of Hilo, with the exception of the country between Honokane and Waipio, where the mountains break off squarely into the sea, leaving no cultivable land. As the land near the sea is all occupied, the only direction in which the plantations can extend is up the mountains; and this, many of them have continually striven to do. Already the land has been cleared to an elevation of from 1,400 to 2,500 feet. In Hamakua there remains above the plantations a strip of forest varying from 1 to 4 miles wide. It is into this remaining strip that some of the plantations wish to extend.

The sugar companies do not own very much of this land. It is owned principally by the Territorial government, which leases it to the sugar companies and gives them permits to clear it. Several requests are pending now for permits to clear land above the present limit.

Now, it is recognized by sugar planters, landowners, and government that a limit exists above which clearing means ultimate disaster

to the sugar industry. In the opinion of some this limit has already been reached. During the early part of the present year an expression of opinion of the plantation men was obtained as to what limit should be set for clearing. Most of them favored a limit below the 2,000-foot contour. Nevertheless, some of the managers are very anxious to extend their plantations beyond this limit.

The opening up of large tracts of forest lands for homestead purposes has also complicated the problem seriously. Several years ago a preliminary trial indicated that coffee could be successfully grown in this region, and the insular government, importuned by those who desired to engage in its cultivation, threw open to settlement several large tracts lying just above the sugar plantations in Hamakua and Puna. Clearing and coffee planting went on rapidly for a few years, but came to a sudden halt when it was discovered that the coffee trees bore only a crop or two and then failed. Something had to be done with the homesteads. The most convenient thing was to turn them over to the sugar plantations, and this in most cases was done. Thus the possibility of using the homestead law for extending the sugar plantations was demonstrated. The pressure for opening tracts, ostensibly for homesteads, has continued. Several tracts have been opened within the past few years, and the opening of others is under consideration. In a great many, probably a majority of cases, the homesteader has sold first the timber and then the cleared land to the plantations, for the settler has found it more profitable to dispose of his homestead in this way and afterwards work for the plantation than to till the land.

Attempts to farm these homesteads have signally failed. The rainfall is too great for some crops, and those which could be grown are usually devoured by insects, which seem to be always present in astonishing numbers. If by chance the homesteader manages to grow a crop he finds it difficult to get it to a shipping point over the mountain roads. The shipping rates to Honolulu, which is practically the only market on the islands, are excessive. And in the Honolulu market it is impossible for the Hawaiian farmer to compete with California in dairy products and cereals. Except for specialized crops, which will have high value in proportion to their bulk, farming in these districts is absolutely without promise of successful returns.

The question may be asked, If sugar is so profitable a crop on this land, what reasonable objection can be raised to cutting away the forest and growing sugar cane upon it? The danger is that the plantations may go so far in the matter as to bring ultimate disaster upon themselves by ruining their water supply and decreasing the rainfall. Many of the plantations now obtain water from the mountain streams for fluming cane to the mills. There is scarcely enough water for this

purpose, and it has been noticed that with the clearing of the lower slopes these small streams have been perceptibly diminished.[a]

The other and far more dangerous result to be feared in cutting away the forest is the modification of climatic conditions so that there will not be enough rainfall to insure the growth of sugar cane. Kohala and Hamakua have barely enough rainfall to produce good crops during the best seasons. Dry seasons cut down the crop till there is often no profit in it. In 1901 these districts produced 52,025 tons of sugar, worth $4,080,505—15 per cent of the entire crop of the islands. In 1902 they produced only 17,079 tons, in consequence of a severe drought which affected the crop greatly. The crop of 1902 is said to have been produced at a loss to the planters. Frequent droughts such as that would soon put an end to the entire sugar industry in these districts, for there is no possible supply of water except rainfall.

Throughout the Hawaiian Islands, but especially in these two districts, the influence of the forest upon both the amount and distribution of rainfall is a matter of common observation and experience. Back of the sugar plantations in Kohala and most of Hamakua the land does not rise above an elevation of 3,000 feet, and therefore lacks the heavy rainfall which results from higher elevations. As the forests have occupied the land above the plantations they to a certain extent have answered the purpose of the mountains in cooling the atmosphere and causing the saturated trade winds to relinquish their moisture over the plantations. The evidence of this influence is convincing, and seems capable of demonstration to some extent by measurement. On the plains of Hamakua and the lower northeast slope of Mauna Kea, where heavy fogs blow over from the ocean and mists are of almost daily occurrence, the top of a single tree condenses enough moisture to make the ground beneath it muddy, or even to cause water to stand, while beyond the influence of the tree top the surface of the ground may be entirely dry. At Punohu, where the Parker ranch maintains a dairy, there is a short row of vigorous eucalypts about 100 feet high. These trees condense so much water that the ground beneath them is always muddy. The ranch has taken advantage of this unusual circumstance by placing beneath the tree tops a roof of sheet iron which collects the water and runs it into a gutter, which leads it into a tank. The water thus collected is sufficient for a large number of stock.

Since the reduction of the forest area has perceptibly diminished

[a] The porosity of the soil in this district is remarkable. Between Waipio and Laupahoehoe there is scarcely a single stream affording enough water to flume cane, and even in portions of Puna, where the rainfall is from 150 to 200 inches per year, there are no streams whatever. The water which falls all sinks directly down and appears in the form of springs only at the edge of the ocean.

the flow of water for fluming, and has decreased and made irregular the rainfall, it is reasonable to expect that the removal of the entire forest would make the water conditions so precarious as to reduce greatly the productiveness of the plantations, if not to ruin them entirely.

NECESSITY FOR THE CLEARING OF LAND.

Speaking of the islands as a whole, it must not be supposed that the removal of the forest has been unnecessary or without beneficial results. It was necessary to clear land in Hawaii for tillage and pasturage, just as it has been in the United States. Without the clearing of large areas of forest land the products of the islands would not, as at present, exceed $25,000,000 a year. The islands would not, as they do now, supply cattle for the present population.

But the point has been reached in most districts where the removal of the forest can not proceed except at the serious injury of existing industries. The best sugar-producing lands and most of the best grazing lands are now cleared. The forest which remains is that which controls, nay, even in some cases gives origin to, the water supply.

IMPORTANCE OF REMAINING FORESTS.

It can not be asserted that the native forests have great commercial value, for the reason that the trees which compose them are not, for the most part, commercially valuable. But for protecting the mountain slopes, and for gathering and distributing a useful supply of water, they have a value which, in the opinion of many, it is difficult to overstate. They lie directly above the cane fields, in many places cover steep, even precipitous slopes, receive from 50 to 200 or more inches of rainfall per year, and possess so great a retentive power that they distribute very evenly this tremendous quantity of water.

The land which depends upon them for a regular supply of water produces, in sugar and rice, crops of immense value. In 1903 the value of the sugar exported from the islands amounted to $25,310,684, or 96 per cent of the total exports. Sugar is the sustaining crop of the islands. Other industries flourish largely because the sugar industry exists.

Large tracts of land suitable for the production of sugar cane still lie out of use because there is no water supply for them. Many of the lands already producing sugar would be far more productive with a more abundant and regular water supply, as is evident from the short crop in Kohala and Hamakua in 1902, which fell to 33 per cent of the normal production because of drought.

In so far as watersheds have been denuded, the results have been disastrous and quickly felt in a dwindling water supply and the decreased productiveness of land. On the other hand, the protection

of denuded watersheds has been accompanied by the most remarkable results in improved water conditions. In some cases the water supply has been in this way so largely increased as to permit of considerable extension of the cane fields.

The abundant evidence that the forest has a direct influence on the increase of rainfall, at least in certain localities, has already been noted.

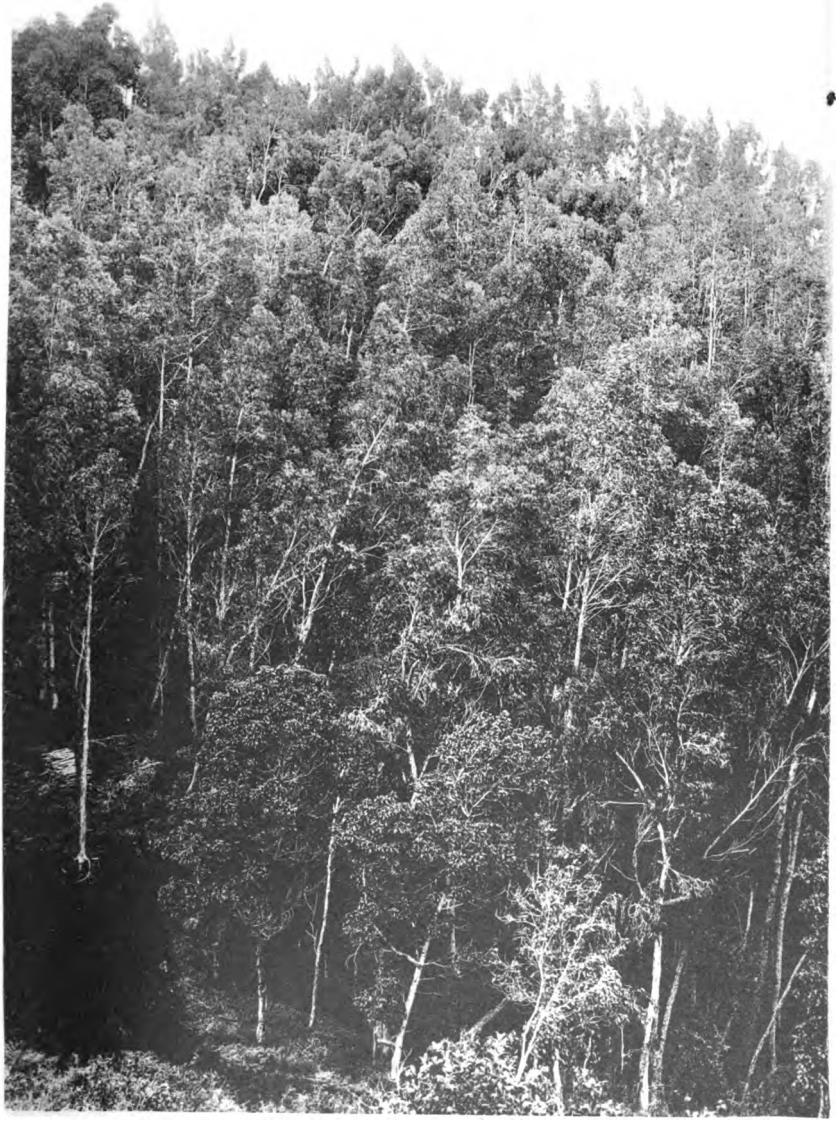
Although the native forests are not of commercial value now, they may be made so within a reasonably short time if placed under management. A large koa forest exists on the slopes of Mauna Kea and Mauna Loa, the products of which would be highly valuable if got out at reasonable expense and placed on a good market. A large part of the rest of the native forests may be brought to commercial value before many years by the planting of valuable lumber trees.

COMMERCIAL INTERESTS CONCERNED IN THE FORESTS.

Those business interests which, like rice and sugar production, are largely dependent upon the mountains for a supply of irrigation water naturally in most cases strongly favor preserving the mountain forests. With them this means a regular and maximum flow of water, which in turn means steady and heavy production of sugar. So strong has been the interest of some of the sugar companies in the preservation of the forests that they of their own account have maintained large forest reserves above their plantations. Notably among them are the Lihue plantation in Kauai, which has had fenced off for ten years a tract of about 10,000 acres, and the Pahala plantation in Kau, Hawaii, which for seven years has maintained a reserve of some 50,000 acres. Private and corporate landowners who lease land to ranches and plantations have also reserved the forest, in some cases making it a condition of the lease that the forest be fenced and fully protected. The B. P. Bishop estate, the largest landowner in the islands, with the exception of the government, has thus reserved five tracts on Oahu and Hawaii, aggregating about 50,000 acres.

Equally noteworthy is the tree-planting policy which has been faithfully carried out by a number of landowners. Rev. Hans Isenberg, president of the Lihue plantation, has planted several large blocks of forest. The most extensive tree planter of the islands is Mr. H. P. Baldwin, of Maui, who for years has systematically planted blocks of forests on his lands on the lower slopes of Mount Haleakala. Mr. Baldwin has now growing many hundred thousand planted trees of eucalyptus, koa, Casuarina, Grevillea, and Java plum.

Occupying a different position from those who desire to keep the forests fully protected are those whose business is not dependent upon the water supply from the mountains and who could really use the



PLANTED EUCALYPTUS FOREST ON MT. TANTALUS. OAHU.

HELIOTYPE CO., BOSTON.

forested land to great advantage, namely, the ranchmen. Some of the very lands whose protection is of vital importance to the sugar plantations are excellent grazing lands, and greatly needed by the ranchmen who use them. And yet the line of personal interest is not so clearly drawn as may be imagined. Many of the ranchmen are also largely interested in the sugar plantations, and while they may be reluctant to give over for forest purposes some of their grazing lands, their other interests lead them to favor strongly, for the islands as a whole, a policy of forest protection. Even the ranchmen who are not concerned financially in sugar production, while not of course forgetting their private interests, are inclined to take a broad view of the situation. They realize that the development of the sugar industry means the development of the whole Territory, and consequently increased and stable markets for their own products. Indeed the ranchmen as a rule take a most reasonable attitude on the question.

It is fortunate indeed that there is no general clashing of interests on the question of forest protection. In the local cases, where general welfare apparently opposes individual interests, a reasonable administration will in almost every instance be able to give entire satisfaction by the exchange of lands held either by leasehold or in fee simple.

THE GOVERNMENT'S INTEREST.

The government's course is plainly to seek such management of the forests as will secure the greatest productiveness of the commercial interests concerned. The plantations need an increased and regular water supply. Therefore, the forests must be protected in order to give it. But the system of protection must not be extended so far that its damage to the ranches will outweigh its benefits to the plantations. Each local problem will have to be worked out fairly and squarely, with due consideration of all the interests at stake.

GOVERNMENT FOREST WORK IN THE PAST.

Hitherto the government has given attention principally to the question of forest planting rather than to the preservation of the native forests. In 1882 an appropriation of $12,000 was made for forest work for the biennial period; later legislatures have continued this appropriation. A nursery was established and many trees have since been grown, some of which have been distributed for planting on private lands, some of which the government itself has planted.

As a result of the government's planting there has been developed on the slopes of Mount Tantalus, facing Honolulu, a fine forest of eucalypts and other trees, covering several hundred acres. More recently a considerable part of the Nuuana Valley, which forms the

watershed for the water system of Honolulu, has also been planted. Although portions of these are handsome examples of planted forests and are rightly highly appreciated by the people of the islands, it may fairly be questioned whether they have been profitable, considering their cost. It is certain that they have in no considerable degree compensated for the loss of the native forests during the past twenty years, and it is equally certain that no amount of planting which the government can afford to do can compensate for these losses under present conditions.

The problem must be solved by first protecting the native forests from the forces which are working their destruction, so that as far as possible nature may accomplish their reproduction, and then by judicious planting in those places where the forest is unable to replace itself.

PROPOSED FOREST SERVICE.

The people of Hawaii almost unanimously favor the immediate institution of a system which will protect and restore the mountain forests. Guided by this emphatic sentiment, the last legislature passed a bill creating a forest service, and outlining to some extent a forest policy. Under the law the responsibility of the service rests on a nonsalaried board of agriculture and forestry, whose duty it is to gather and publish information concerning the forests of the islands, to provide for the introduction, propagation, and planting of useful forest trees, to establish forest reserves so far as necessary for the protection, extension, and utilization of the forests and the safeguarding of the sources of water supply, and to protect the forest reserves from damage by cattle and other agencies.

The board is authorized to appoint a superintendent of forestry, who is to be a trained forester, and under the direction of the board is to have immediate charge of all forest work. The superintendent of forestry is to have such paid assistants and rangers as the board may find necessary for handling matters connected with the forests and forest reserves.

The board is also to appoint in each district one or more consulting foresters, who are to serve without pay and advise with the board concerning forest matters in their districts.

A biennial appropriation of approximately $28,000 per year has been made to carry the law into effect.

The board of agriculture and forestry has invited the Bureau of Forestry of the United States Department of Agriculture to assume an advisory position in connection with its future policy. On the nomination of the Bureau a trained forester has been appointed as superintendent of forestry, and has already entered upon his work.

Appointments of assistant foresters and rangers are being made as rapidly as the needs of the service require.

FUTURE POLICY.

No attempt can be made here to do more than point out the main principles which must govern the future policy of the islands in the maintenance of a forestry system. These are as follows:

FOREST RESERVES.

Nothing less will be effective toward the preservation of the Hawaiian forests than a carefully worked out system of forest reserves, which will include practically all of the mountain forests previously mentioned, as well as some potential forest land which has been denuded. This reserve system should be established as soon as possible, beginning probably in Kula, Hamakua, and Kohala, since in those districts there is greatest immediate need of protection. The Territorial government owns most of the land which should go into the reserves, but the government land is largely held by individuals or companies under leases, some of which will not expire for a number of years. The lessees of many important tracts are willing to relinquish the forest land to the government in exchange for reasonable extension of leases, or for new leases on other lands. Almost all of the reserves will also need to include some land held in fee simple by individuals or companies. Here, again, the only solution of the question is by the government exchanging with the private owners.

It is evident that each reserve will have to be made, a part at a time, as satisfactory exchanges can be made, both in leased and owned lands. The possibility of such exchanges is entirely dependent upon the cooperation of the government with the individuals interested. Good results will be accomplished only when both parties fully understand the importance of the proposed reserve, and enter into negotiation solely to secure fair and equitable exchanges.

As soon as a reserve is formed, all cattle should be driven out and the portions which are accessible to cattle should be fenced. Those wild cattle which can not be driven out should be shot. An effective ranger service should be put into effect to keep stock and fire out of the reserved forest. As soon as practicable, on each reserve men should be employed to hunt down and exterminate the wild goats.

PLANTING.

With the reserves well protected, the forest will replace itself on many of the damaged areas, as reproduction under some conditions takes place rapidly. Where the forest will not replace itself, planting

will be necessary, and can be done with direct profit to the islands if commercially valuable species are made use of and are planted in the right situation. Conditions prevailing at 5,000 to 6,000 feet in Kula, Hamakua, and Kau strongly indicate that Pacific coast species, such as redwood and red fir, would do exceedingly well. Eucalyptus, Monterey cypress, Casuarina, Grevillea, and several other trees have already shown their adaptability for these situations. It is especially important to find trees suited to these and higher elevations, because the native forest is often deficient at such elevations, although the land is good forest land and can never be used for other purposes. In some situations it may be desirable to plant species bearing edible fruit, such as the alligator pear and breadfruit.

For the present, forest planting should wait on the formation of the reserves. Forests already planted on Mount Tantalus and in Nuuana Valley should be cared for, and the nursery should be maintained, but no extension of planting or of the nursery should be attempted until the reserve system is fairly under way.

LUMBERING.

As soon as practicable, an examination should be made of the koa forest on the east slopes of Mauna Kea and Mauna Loa, to determine whether or not it is feasible to build a road to it and locate a sawmill in it for the purpose of lumbering the mature trees. Some of the koa is without doubt very fine, and would form a source of revenue to the Territory, to which it belongs, if it could be got out without great expense. The law provides that any moneys which shall accrue from such products shall be held available as a special fund for the preservation, extension, and utilization of forests and forest reserves, in the same manner as moneys appropriated by the legislature. This makes it desirable as soon as possible to make the forest revenue producing, so far as this is compatible with its preservation for other useful purposes. It is believed that the situation and composition of the koa forest is such that the removal of the mature trees could be accomplished without damage either to reproduction or to water supply.

CLEARING.

The law makes it mandatory upon the board of agriculture and forestry to pass upon the disposition of any public land, not including roads and city lots. All leases and sales of forest land, carrying the right to cut timber or clear the land, must therefore be approved by the board. Since the clearing of land for the extension of canefields and for homesteads is at the present time making irreparable inroads upon the virgin forest in important localities, it is of special consequence for the board to act with the greatest caution on all permits to

clear land. The only safe attitude for the board to take under present conditions is to assume that all the Government's forests should remain intact, and it should recede from this position only in those individual cases where the contrary is plainly proved.

EXTERMINATION OF INSECT PESTS.

The effective work which has been done by the entomological service of the islands toward the extermination of certain kinds of injurious insects suggests the possibility of ridding the forests of some of the insects which are devastating them, and furnishes ground for the recommendation that the board, in connection with its entomologists, take the matter into consideration.

ASSISTANCE TO LANDOWNERS.

Throughout the islands there is great interest on the part of both individual and corporate landowners in the development and preservation of forests. And yet the individual is often at a loss to know what trees to plant for his situation—where to get them, how to plant successfully, and how to care for the planted or native forest. This is information which only the trained forester can give. For lack of it some landowners have made no effort in forest work; others have worked with meager results.

It should be a part of the forest policy to give such assistance to landowners as the need requires. Studies should be made on the ground to determine what trees to plant and what methods to adopt, both in the establishment and in the care of woodlands. In many cases it will be beneficial, if not necessary, to assist in procuring seeds and plants, especially those which have to be procured outside of the islands. In so far as the Government nursery is made use of for the production of trees for planting on private lands, the trees should be of valuable economic kinds, and where distributions are made from the nursery the planting should be done under the supervision of the superintendent of forestry.

COOPERATION WITH THE BUREAU OF FORESTRY.

The close relation existing between the forest service of the islands and the Federal Bureau of Forestry can be maintained with direct benefit to each. It will strengthen the insular service to have the advice and support of the Bureau in dealing with the problems which it will have to meet. On the other hand, such cooperation will enable the Bureau to keep in as close touch with the forest administration of these important islands as it does with forest affairs in the different States.

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